

CARDINAL UNIT 1 LARGE SCALE SELECTIVE NON-CATALYTIC REDUCTION DEMONSTRATION PROJECT

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American Electric Power plans to perform a full-scale demonstration of a Urea-based Selective Non-Catalytic Reduction (SNCR) system on Cardinal Unit 1 in Brilliant, Ohio. Cardinal Unit 1 is a 600MWe opposed-wall dry bottom pulverized coal-fired boiler which began service in February, 1967. This unit is being retrofitted with Low NO_x Burners (LNB's) during its scheduled fall 1998 outage. The SNCR system will also be installed during this outage. The overall goal for this project is to demonstrate the applicability of Urea based Selective Non-Catalytic Reduction technology on a 600MW steam generator at a cost comparable to fuel switching or blending. The specific objective is to reduce NO_x emissions by 30% while minimizing ammonia slip to <5ppm.

AEP and the utility industry have no experience with the application of SNCR technology on large utility steam generators. The largest domestic coal fired

application thus far has been on a 321MW unit with twin furnaces. To date, the industry has utilized Low NO_x Burners (LNB's) to reduce NO_x emissions to the levels required by the Clean Air Act Amendments. In addition to providing an additional increment of NO_x reduction, SNCR offers the following potential benefits:

- 1.) lower capital costs when compared to other post-combustion reduction alternatives,
- 2.) lower operating cost since the cost is based on usage, and
- 3.) the ability for it to be integrated with future emissions control technologies, such as SCR.

American Electric Power Company (AEP) is one of the nation's largest investor-owned electric utility systems with over 24,000MWe generating capacity. American Electric Power Service Corporation, the management and technical subsidiary of AEP, is an internationally recognized utility and architectural & engineering firm specializing in energy projects of all types, and will be the prime contractor for this project. AEPSC is currently serving in this capacity on LNB installations across the AEP system. The modifications to be undertaken at the Cardinal Plant demonstrate AEP's environmental stewardship and commitment to the development of technologies, such as SNCR, and to implement cost-effective NO_x reduction techniques.

SELECTIVE NON-CATALYTIC REDUCTION

The SNCR process is a post-combustion NO_x reduction method that reduces NO_x through a controlled injection of reagent, in this case urea, into the combustion products of fossil-fired boilers. Conceptually, the SNCR process is simple. A nitrogen-based reagent, in our case urea, is injected into and mixed with the combustion products. The chemical reacts selectively in the presence of oxygen to reduce the oxides of nitrogen (NO_x) primarily to molecular nitrogen (N₂) and water (H₂O). The reaction between urea and NO_x occurs within a specific range of temperature, known as the temperature window. If the temperature is too low, reaction rates are too slow and by-product emissions can become excessive. At high temperatures, NO_x reduction and chemical utilization are low. This optimum temperature window is specific to each application. In addition to temperature, residence time within the temperature window, flue gas velocity and directions, and baseline NO_x affect the process performance.

The SNCR technology must be applied based on a detailed analysis of boiler operations and behavior. NFT utilizes computational fluid dynamics (CFD) and chemical kinetic modeling (CKM). The CFD model simulates flue gas flows and temperatures inside a unit while the CKM model calculates the reaction between urea and NO_x based on temperature and flow information from the CFD model. The model results are validated by field measurements. A combination of these two models determines the optimum temperature region and the optimum injection strategy for distributing the reagent throughout the entire load range.

PROJECT ORGANIZATION

A number of organizations are involved in the project. As mentioned above, AEPSC is the prime contractor. The SNCR system will be provided by Nalco/Fueltech (NFT); Nalco/Fueltech is also co-funding the project. Nalco/Fueltech, starting from EPRI's patent on Urea SNCR, has developed, designed and installed over two hundred NO_x reduction systems over the past eight years. The Electric Power Research Institute has also committed to support this project providing co-funding and acting as liaison to other interested EPRI-member utilities. EPRI has currently enrolled seven other utilities as sponsors.

DISCUSSION

One of the greatest difficulties of applying SNCR technology is being able to continuously inject the reagent within the optimum temperature window. The temperature window moves through the unit as load is varied. In addition to this movement with load, the temperature profile is not uniform across the unit at any one elevation. Changes in fuel type, mill in service patterns, furnace cleanliness, and O₂ level can also cause variations in the location of the optimum temperature window. To understand and overcome this difficulty, the temperature mapping and computer modeling were completed as the first step of the project. This step provides the information necessary to identify the required number, and the best physical locations for installing the different levels of injectors. The modeling also provides the guidance on reagent flow rate at each location and load. It is in this manner that the reduction and utilization are optimized while the slip is minimized.

An improper operation of SNCR can result in undesirable side-effects. When injected above the temperature window, the chemical utilization decreases, thus wasting reagent. At lower temperature than the window, high NH₃ slip can result. Reactions between NH₃ and SO₃ can result in ammonium sulfate or bisulfate formation, and can lead to air preheater fouling and/or pluggage. Additionally, NH₃ can react with HCl or SO₂ downstream of the stack to form a detached visible plume. The SNCR system for this project will be designed with an enhanced-control logic with input signals such as flue gas temperature, steam flow rate, NO_x, etc., that will reliably and accurately reflect boiler conditions with minimal lag time. These enhancements are expected to overcome these issues.